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The effect of a sedimentary wedge on earthquake ground motions: The influence of eastern U.S. Atlantic Coastal Plain strata

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Coastal regions of the eastern U.S. are underlain by a wedge of partially consolidated Atlantic Coastal Plain (ACP) marine sedimentary strata overlying a bedrock of crystalline or indurated sedimentary rocks. The ACP strata extend more than 200 km inland, tapering landward from as much as 1 km near the coast. Unconsolidated, shallow sedimentary strata strongly influence earthquake ground motions due to low seismic impedance and strong reflections from the bedrock contact. Site response estimates primarily determine high-frequency amplifications from shear-wave velocities in the upper 30 m (Vs30), but thicker sedimentary sequences can increase longer-period ground motions important to large structures. Here we use data from continental-scale seismic experiments that span the ACP (e.g. Eastern North America Margin [ENAM], Earthscope Transportable Array) to examine the influence of ACP strata on earthquake ground motions. We use teleseismic and regional earthquake recordings to compute spectral ratios relative to bedrock sites. Thin ACP strata produce fundamental resonance peaks at high frequencies (>5 Hz), but the fundamental peaks decrease to about 0.45 Hz as the sediments thicken to about 500 m. Amplitudes of the fundamental resonance peaks decrease as the strata thicken, but even coastal sites show amplification factors as great as 5. In addition, we use the frequency of the resonance peaks to invert for an average velocity function within the ACP strata. A smaller array within the city of Washington, DC, which is underlain by a wedge 0- to 270-m-thick ACP strata, shows large amplifications at frequencies of 0.7 to 5 Hz. These amplifications likely contributed to the widespread damage to the city during the relatively modest, M5.8 Virginia earthquake in 2011. This work confirms amplification of short-period ground motions by thin ACP strata, and documents longer-period amplifications caused by thick sedimentary sequences beneath coastal regions of the eastern U.S.